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THE NEW NEW FINANCIAL THING: THE SOURCES OF INNOVATION BEFORE AND AFTER STATE STREET

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ABSTRACT

This paper examines the sources of financial innovations between 1990 and 2002, using Wall Street Journal articles as indicators of innovations. No evidence suggests that larger firms are particularly innovative; in many specifications, there is a disproportionate representation of smaller firms among the innovators. Less profitable firms and those with stronger academic ties also innovate more. The elasticity of innovation with respect to size appears to have increased sharply since the State Street decision that greatly accelerated the rate of financial patenting. I conclude by exploring how the origins of financial patents resemble or differ from those of innovations.

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The significance of financial innovation is widely recognized. Many leading scholars, including Miller (1986) and Merton (1992), have highlighted the importance of new products and services in the financial arena. Empirically, Tufano (1989) showed that of all public offerings in 1987, 18% (on a dollar-weighted basis) consisted of securities that had not been in existence in 1974. These innovations are not just critical for firms in the financial services industry, but also impact other companies: for instance, enabling them to raise capital in larger amounts and at a lower cost than they could otherwise.

Yet despite this importance, the sources of financial innovation remain surprisingly poorly understood. In a recent review article, Frame and White (2003) highlight the paucity of empirical research in this area. While innovation in manufacturing industries has inspired literally thousands of academic studies, the authors are only able to identify 39 empirical studies of financial innovation. Moreover, this literature is highly concentrated on the "back end" of the innovation process, focusing largely on the diffusion of these innovations, the characteristics of the innovation adopters, and the consequences of innovation for firm profitability and social welfare. The authors can only identify two papers on the origins of innovation, Ben-Horim and Silber (1977) and Lerner (2002). This paucity of research can be contrasted with the abundant literature on the sources of manufacturing innovation.

This paucity of research is particularly puzzling given the likelihood that the dynamics of financial innovation are quite different from that in manufacturing. The financial services industry has historically differed substantially from the bulk of manufacturing industries in regard to the ability of innovators to appropriate their discoveries. Until recently, firms have been very limited in their ability to protect new ideas through patents. As a result, new product ideas have diffused rapidly across competitors (Tufano (1989)). Second, product innovations have been typically subject to a great deal of exposure, due to the need to market these products to potential customers and (frequently) to file documentation with public regulatory agencies. Third, firms in many segments of the financial services industry frequently engage in collaborative activities, whether syndications of particular innovations or collaborations to market new products. Such collaborations—while certainly also seen in manufacturing industries—may shape the incentives to innovate and nature of innovations. Together, these considerations suggest the need to examine financial innovation as a phenomenon in its own right.

As Frame and White point out, one of the major barriers to the study of financial innovation has been a paucity of data. Studies of manufacturing innovation have traditionally focused on R&D spending and patenting. Given the rareness with which financial service firms report R&D sending and the infrequency of financial patents until recently, these measures are unlikely to be satisfactory. This paper seeks to take a first step towards addressing this gap, by developing a measure of financial innovation based on news stories in the *Wall Street Journal*.

The analysis proceeds in two parts. First, I explore the economic characteristics that are associated with financial innovation, seeking to test a number of hypotheses suggested by the innovation literature. The second part examines one specific regulatory change, the *State Street* decision of the late 1990s. While financial patents were awarded prior to the late 1990s, this litigation dramatically changed the financial service firms' perception of the validity and value of these awards. (See Appendix A for a discussion of this case and its implications.) I examine whether this change in appropriability conditions has affected the type of firms pursuing innovations.

Several conclusions emerge from the analysis:

- Contrary to representations in the earlier literature, financial innovation has been characterized by an even participation of firms across the size spectrum, or even a disproportionate representation of smaller firms. More specifically, a doubling in firm size is associated with less than a doubling in innovations generated in most regression specifications.
- Firms that are less profitable in their respective sectors are disproportionately innovative. This result is consistent, for instance, with depictions by Silber (1975, 1983).
- While little evidence exists of firms translating localized knowledge spillovers from their peers into more innovations, firm with ties to academic institutions appear to be disproportionately more innovative.
- The years since the *State Street* decision are characterized by an increased domination of innovation by large firms. The elasticity of innovation with respect

to size has increased sharply in this period. Some evidence suggests that the academic connections may have declined in importance as a spur to innovation.

- This increasing role of larger firms in innovation does not appear to be a consequence of who is filing for patents, which mirrors the population of innovators in many respects. Other possible explanations include that the value of patent awards may differ for firms in different size classes, or that this shift is a consequence of an unrelated change in the economic or regulatory environment. Less academically connected firms appear to be more frequent patentees.

Two limitations should be acknowledged at the outset. First, the time span covered in this study is relatively limited, from 1990 to 2002. This choice implies that the number of major regulatory and tax policy changes during the period under study was quite modest, and the identification of their consequences challenging. Instead, I focus on exploring the impact of only one major change, the emergence of financial patenting in the late 1990s. There is no reason, however, that this methodology could not be extended to a longer dataset, which would allow the more ready identification of these effects.

The second limitation related to the methodology employed. This paper focuses on developing a number of "stylized facts" about financial innovation. While many of the studies of manufacturing innovation have proceeded in a similar manner, others (e.g., Kortum (1997)) have sought to develop structural models of patenting, productivity, and R&D. Reflecting the early stage of the study of financial innovation and the lack of many meaningful measures of innovative performance, a simpler approach seemed desirable.

The organization of this paper is as follows. Section 1 describes the hypotheses that will be tested in the paper. The development of the dataset is summarized in Section 2. Section 3 presents the key patterns of financial sector innovation. The changes around the *State Street* decision are analyzed in Section 4. The final section concludes the paper.

1. Hypotheses

In this initial section, I outline the hypotheses that motivate the analysis. I highlight the extent to which the analyses of financial innovation undertaken below have been anticipated in earlier theoretical and empirical work on manufacturing innovation.

In the first analysis, I focus on three hypotheses regarding the determinants of differences in the innovation rate across firms. These relate to the consequences of the firms' competitive positions, capital constraints, and abilities to access knowledge spillovers. In the second analysis, I examine how a change in the ability to protect discoveries affected innovation. Each of these topics has been explored in the theoretical and empirical literature on manufacturing innovation, and some in the theoretical literature on financial innovation. While this review is not intended to be exhaustive (Cohen (1995) provides a comprehensive overview of literature on manufacturing innovation, and Allen and Gale (1994) and Tufano (2003) on financial innovation), it can hopefully suggest the broad outlines of the literature.

Firm competitive position. This literature has most frequently examined how firms' rate of innovation varies with two aspects: their size and age. The relationship between firm size and innovation has been a topic of enduring interest to economists at least since Schumpeter's (1942) argument that large firms were the ideal manner in which to pursue innovation.[1] Whatever the advantages of small firms for insuring intense static price competition, he asserted, they were unlikely to have the incentives to engage in long-term R&D if much of the rents were likely to be subsequently competed away.

While the empirical literature analyzing this question has been voluminous, few distinct conclusions have emerged. An illustration of these frustrations can be seen by comparing the two most comprehensive studies in this literature, Bound, *et al.* (1984) and Cohen, Levin, and Mowery (1987). While Bound and his co-authors found that R&D-intensity was highest among very small and very large firms, the latter paper found that once industry effects were controlled for, R&D intensity did not change with firm size. Acs and Audretsch (1988), using a database of articles about innovations, suggested that small firms disproportionately contribute to innovative activity.

A number of theorists have suggested that younger firms may be more effective at introducing new products. Holmstrom (1989) argued that the established corporation primarily exists to fulfill production and marketing goals and that to effectively pursue these goals it has to organize in a way that compromises incentives to innovate. Providing

[1]This work has also inspired many cross-industry studies of how innovation at the industry level differs with market concentration.

incentives for both types of activities within one organization is more costly than providing them through separate organizations. Aron and Lazear (1990) presented a model in which new firms pursue less risk-averse strategies and are hence more likely to undertake radical new research programs and to introduce new products.

Prusa and Schmitz (1994) tested these theories by examining the introduction of new software products. The authors suggested that new firms appear to be more effective at creating new software categories, while established firms have a comparative advantage in extending existing product lines. Similar conclusions emerged from Henderson's study of the photolithographic industry (1993), which suggested that established companies failed to successfully pursue major technological opportunities.

The relationship between firm characteristics and innovation has not attracted a great deal of attention in the theoretical literature on financial innovation: much of the work has ignored the effects of financial institutions. The works that have appeared are mixed in their conclusions. Bhattacharyya and Nanda (2000) argued that investment banks with greater market power and more secure relationships with their customers are likely to innovate. Silber (1975, 1983), on the other hand, argued that those firms that most constrained by market imperfections—which he implies will be the weakest and smallest firms—should be the most innovative.

Financial constraints. Another extensively scrutinized question has been the extent to which financial resources affects firms' ability to pursue innovations. Since

Arrow (1962), it has been understood that the substantial information problems surrounding R&D projects make it difficult to raise external capital to finance them. As a result, firms with promising projects may be unable to pursue them. This intuition is formalized in models such as Stiglitz and Weiss (1981) and Myers and Majluf (1984).

Many early studies suggested a relationship between cash flow and R&D spending, a finding that could be interpreted in various ways. Recent works have examined these issues more systematically. Himmelberg and Peterson (1994) looked at a panel of small firms, and showed that the sensitivity of R&D investments to cash flow seems to be considerably greater than that of physical investments. But the bulk of the attention has focused on the impact of leverage on R&D spending. Hall (1990) showed that firms that increase their leverage tend to reduce R&D spending. Similar conclusions emerged from Greenwald, Salinger, and Stiglitz (1992). This topic has been little explored, however, in the theoretical literature on financial innovation.

Ability to Access Knowledge Spillovers. An extensive theoretical literature (e.g., Romer (1986)) has argued that spillovers of technological knowledge are an important spur to future innovation. As Krugman (1991) and others have hypothesized, these spillovers—particularly of tacit knowledge—are likely to be geographically concentrated.

Jaffe, Henderson, and Trajtenberg (1993) demonstrated that patents are more likely to be cited in patents awarded to other entities in the same region, an effect that they suggest is consistent with the localization of knowledge spillovers. Similarly, Audretsch and Feldman (1996) showed that not only is innovative activity more concentrated than manufacturing, but that this is particularly the case in industries where knowledge spillovers are important.

Another source of spillovers may be ties to academic institutions. Cohen and Levinthal (1989) hypothesized that firms may seek to build close connections to academia to boost their "absorptive capacity." The authors hypothesize that these activities enhance firms' abilities to interpret scientific discoveries and to translate them into innovations.

Some supporting evidence for these claims has been found in the life sciences. Henderson and Cockburn (1996) showed that pharmaceutical firms that embraced scientific-based research were particularly successful in developing new drugs. In related work, they showed that other practices—such as co-authorship between corporate scientists and public sector researchers—are also associated with enhanced drug discovery. Zucker, Darby, and Brewer (1998) demonstrated that the formation of new biotechnology firms in regions is largely driven by the presence of academic science. The impact of knowledge spillovers on innovation in the financial services industry has been little scrutinized, from either a theoretical or an empirical perspective.

Appropriability. Beginning with Nordhaus (1969), much of the theoretical economics literature has assumed an unambiguous relationship between the strength of patent protection and the rate of innovation: an increase in the amount of patent protection offered should increase the rate of innovation. A crucial assumption behind such findings is that the nature of the patent award does not affect the incentives of subsequent researchers to pursue innovations. This assumption has been relaxed in a line of work on sequential innovation, beginning with Scotchmer and Green (1990). When the nature of protection offered the initial innovator affects the incentives of subsequent researchers, the conclusions may change. This literature suggests that strong patent protection may actually lead to significantly less innovation than no patent protection at all. Gallini (1992) considered the impact of increasing patent protection when rivals can "invent around" previous discoveries (at some cost). This model suggested that the relationship between patent strength and innovation will display an "inverted U" shape.

This impact of appropriability conditions on innovation has attracted considerable empirical attention, but the results have been mixed (see Gallini (2002) for a review). Many studies of specific policy changes (e.g., Sakakibara and Branstetter's (2001) study of the 1988 strengthening of patent protection in Japan) have proven to be inconclusive. This literature has also sought to assess what types of firms are likely to benefit from stronger patent protection. Here too, a clear conclusion is elusive. Hall and Ziedonis (2001) argued that the strengthening of patent protection in the U.S. over the past two decades harmed innovation by smaller firms in the semiconductor industry because they could not participate in the cross-licensing agreements that the major firms entered into. Merges (1996), on the other hand, argued that the strengthened intellectual property regime allowed small biotechnology firms to more readily attract venture capital financing and enter into alliances with pharmaceutical firms.

This issue, as well, has been little explored in the context of financial innovation. One exception is Herrera and Schroth (2002), who showed in a theoretical analysis that even when inventions cannot be patented, investment banks will have considerable incentives to develop new products.

To be sure, the list of potential explanations for financial innovation that I will examine here is far from exhaustive. The most important omission is demand side shifts, whose importance in spurring innovation was highlighted by Schmookler (1966). For instance, the emergence of a new high-technology industry with particularly severe informational asymmetries may spark the introduction of new financial instruments geared to their particular needs. Similarly, alterations to the tax code or regulations may stimulate corporations to demand new financial products and services.[2, 3] I cannot really effectively capture these demand side shifts here, and so will ignore them. To the extent to which they are correlated with the independent variables, these may introduce an omitted variables bias.

[2]The extensive theoretical literature examining these issues is reviewed by Harris and Raviv (1989) and Allen and Gale (1994). For illustrations of financial innovation triggered by the special characteristics of the biotechnology industry, for instance, see Beatty, Berger, and Magliolo (1995) and Chacko, Tufano, and Vetter (2001).

[3]It is unlikely, however, that tax policy shifts will affect the supply curve for innovations. Under the Internal Revenue Code § 41, the credit is limited to "research in the laboratory or for experimental purposes, undertaken for discovering information, technological in nature." In a series of decisions, tax courts have held that this definition does not include R&D performed by financial service institutions or involving software development more generally. Recent examples include *Tax & Accounting Software Corp. v. U.S.*, 301 F.3d 1254 (10th Cir. 2002) and *Eustace v. Commissioner*, 2002 U.S. App. LEXIS 25530 (7th Cir. 2002).

2. Developing the Data-Set

As highlighted in the introduction, traditional measures of innovative activity—e.g., R&D spending and patenting—are unlikely to be very illustrative in this setting. An alternative measure is needed. This section describes the manner in which I develop the database of financial innovations.

A. Identifying Innovations

My goal is to examine financial innovation before and after the *State Street* decision. This is a challenging task. Not only are traditional approaches inadequate, but the listings of new securities compiled by Securities Data Company (which maintains the leading database of corporate new issues) are inadequate. First, much of the innovation in financial services has taken place outside the realm of publicly traded securities, such as new Automatic Teller Machines and insurance products. Second, as Tufano (2003) points out, many of the "novel" securities identified in the SDC database are minor variants of existing securities, often promulgated by investment banks seeking to differentiate themselves from their peers.

As a result, I need an alternative measure of innovative activity. I employ an approach here—originally developed in Kortum and Lerner (2003)—of examining articles in the *Wall Street Journal* concerning financial invention or innovation. I compile all such articles between 1990 and 2002 that related to new financial products, services, or institutions. While such a measure is far less frequently used as a measure of innovation than R&D and patents, I am not the first to use counts of stories to study innovations: Acs and Audretsch (1988), Chaney, Devinney, and Winer (1991), and Cardinal and Opler (1995) are earlier examples. The latter two papers use counts of stories exclusively from the *Wall Street Journal.* Given the *Journal*'s intensive coverage of the financial services industry, the use of this measure seems particularly appropriate here.

In order to undertake this analysis, it is critical to have a consistent definition of what constitutes an invention and an innovation.[4] According to the relevant definition in *Webster's Dictionary*, an invention is "an original contrivance or apparatus," while an innovation refers to the "introduction of something new." I take inventions to be new products or processes, while innovations refer to the first time an invention is put to use. I wish to count both.

Even if I ignore the distinction between invention and innovation, in many cases either definition is too vague to be useful in deciding which entries to count. To address this problem, first I define some terms which scholars have found useful for delineating what counts as an invention or innovation. From this literature (e.g., Schmookler (1966) and Jewkes, Sawyers, and Stillerman (1969)), I can find definitions which are much more concrete than the dictionary's. These authors make a distinction between scientific and

[4]The following six paragraphs are from Kortum and Lerner (2003). Sam Kortum originally wrote the first three paragraphs. A related concern was insuring consistent coding of the databases by the research assistants. Before beginning working on the database, each research assistant coded the same test section. The responses were compared to the author's coding of this section. When necessary, a second test section was coded as well. Frequent team meetings discussed questionable cases and helped insure consistency.

technological knowledge, the former being a set of general principles while the latter is a set of specific techniques, products, and processes. Scientific knowledge is expanded by discoveries about how the world works while technological knowledge expands via inventions. I want to count inventions but not discoveries.[5]

Schmookler makes the critical distinction between innovation and imitation:

> When an enterprise produces a good or service or uses a method or input that is new to it, it makes a *technical change*. The first enterprise to make a given technical change is an *innovator*. Its action is *innovation*. Another enterprise making the same technical change later is presumably an *imitator* and its action, *imitation* (pg. 2, emphasis in the original).

I do not want articles about imitation. Once invented, several firms can in principle use a technique at once without diminishing its performance. Thus, I do not want to include articles about firms that are simply expanding production. Some new products may be a direct consequence of scaling up production. For example, as the number of investment bankers at financial institutions increases, it is obvious that more transactions can be underwritten. Such behavior is simply expansion or replication of an existing production process. I would, however, count a story about the bank's development of a new product.

For the most part, I will not attempt to evaluate the importance of any invention or innovation, but will simply assume that if the *Wall Street Journal* finds it worth writing about it should be included. I use the *Wall Street Journal* due both to the consistency in its editorial mission over the years and the thoroughness of its indexing, which should

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[5]Scholars also distinguish between invention and development, the latter being concerned with getting an invention to work in practice. I will not worry about this distinction (in the same way I want to include both inventions and innovations).

lead to fewer biases. (The *New York Times*, for instance, launched a series of regional editions over the same period, and greatly enhanced their coverage of local news from outside the New York metropolitan area.) The specific rules I use for including or excluding innovations are contained in Appendixes B and C.[6]

I consider the individual article as the unit of observation. I include multiple articles even if they concerned the same innovation. I assume that articles about new products and services were in fact about innovations unless the article explicitly suggests otherwise. In other words, I err on the side of including new products even if they might be imitations.

One natural concern is that the fluctuations in stories about innovations in the *Journal* may have had little to do with any change in the fundamental innovativeness of the American financial services industry. For instance, the *State Street* decision may have triggered firms to disclose more discoveries, since they no longer needed to rely as heavily on trade secrecy to protect ideas. To address this concern, I coded the extent to which the stories unambiguously represented a true innovation. I employed an (admittedly subjective) three-part classification scheme, denoting stories As, Bs, and Cs, depending on the extent to which I was sure that it described an innovative contribution. No evidence of changing quality appeared in the tabulations: for instance, between 1990

[6]One criterion in the appendices should be highlighted. I focus on innovations in the United States, whether by a foreign or domestic firm. I make this choice because I believe the *Wall Street Journal*'s coverage of U.S. innovations is much less likely to be affected by selection biases. I also take this route because this measure is closely analogous to the U.S. patents analyzed below (which can be applied for by any entity, foreign or domestic, but only cover the United States).

and 1998, 69.9% of the stories were classified as either an "A" or a "B." After the *State Street* decision (between 2000 and 2002), 68.5% of the stories were so classified.

I also talked with a current and former reporter of the *Wall Street Journal* in order to understand biases that may have been at work in the selection of stories. They highlighted two issues, which may make small firms appear more or less innovative than they actually are. First, lacking the distribution networks of established firms, small financial institutions may have more aggressively sought publicity for their discoveries. Second, the *Wall Street Journal* pays particular attention to the largest financial institutions, often assigning dedicated reporters to cover these firms. This intense coverage might have led to more articles about innovations by larger firms. They also noted that a significant—though difficult to ascertain—number of innovations never make it into the *Journal*: for instance, the development of a new pricing methodology for mortgage-backed securities by the proprietary trading group of an investment bank or a hedge fund is unlikely to be publicized.

I identify stories between 1990 and 2002 using two sources. The *Wall Street Journal Index* (WSJI) is a printed volume with at least one entry for each article in the *Wall Street Journal*. In any given year, the entries in the WSJI are organized by topic. The same article may appear more than once as it may relate to more than one topic. Each WSJI entry contains a short summary of the article from which one can evaluate whether the article concerned an invention or innovation. Unfortunately, the length and detail of these summaries deteriorated over the 1990s, as most readers began relying on on-line sources. As a result, I also identify stories through a second source, the Factiva database. I search this database using a large number of keywords associated with new discoveries or product or service introductions.

I combine the stories from both sources to construct the database. In each case, I identify the entities featured in the story. In some cases, articles list large numbers of firms (e.g., a review article recapping a set of innovations). In these cases, I identify only the four entities most prominently featured in the story, based on the number of words devoted to each entity in the original article. (In case of ties, I employ the entities mentioned earliest in the article.) In some cases, these entities included government bodies (e.g., "World Bank issues novel security," "Commodities Future and Trading Commission approves new derivative contract"), exchanges, and other non-profit organizations.

Table 1 summarizes the distribution of articles and entities in the dataset. Panel A summarizes the distribution of the 651 news stories meeting our criteria. No clear time trend is evident from the data. Panel B presents a breakdown of the types of innovations reported on. The bulk of the stories relate to the underwriting of novel securities or trading technology (33.5%), asset management (26.2%), and retail banking or mortgages (11.6%). Panel C shows the breakdown of stories over time, now focusing solely on the 387 stories about entities that listed in Compustat (as discussed below, I will focus on this subset of firms). The final panel shows the breakdown of the industry of the innovators, by three-digit Standard Industrial Classification (SIC) code. Not surprisingly, the three most common classes are classified among "finance, insurance, and real estate": securities brokers and dealers (23.5%), commercial banks (22.3%), and other non-depository credit institutions (8.2%). Following these categories, however, are a wide variety of industries, ranging from computer programming to publishers to motor vehicle manufacturers.

I assess the importance of these announcements by examining the market reaction to these stories. In all, there are 305 distinct dates on which stories appear about entities whose stock price is included in the databases of the Center for Research in Security Prices. (In some cases, Compustat-listed firms are not found in CRSP; in others, multiple stories about innovations at a single firm appear within one week of each other.[7]) The firms' equity returns around the time of the *Wall Street Journal* story are consistently positive and statistically significant. For instance, when I estimate a market model using a (-1, +1) window centered on the date the story appeared, the average cumulative abnormal return is +0.63% and the associated t-statistic is 2.68. (The result is significant at the one-percent level using a one-sided t-test.) (All observations must have at least three observations between one and twelve months before or after the event window, which is used to compute the correlation with the market. The value-weighted CRSP index is used as a benchmark.) The results are similar when I use longer or shorter windows, alternative indexes, or different specifications. For instance, when I estimate a market-adjusted model over the (-2, +1) window, the average cumulative abnormal return

[7]When multiple stories appear about a company within five trading days of each other, I only employ the first observation. The results are robust to using the latter observation or deleting these overlapping observations entirely.

is +0.84% with an associated t-statistic of 3.04. These results suggest that the innovations are indeed significant ones to the firms in the sample.

B. Supplementary Data

In addition to the database of innovations, I collect a variety of additional information. These come from three sources: databases derived from U.S. Securities and Exchange Commission filings, the U.S. Patent and Trademark Office's (PTO) on-line patent database, and academic-practitioner finance journals.

In order to effectively characterize the firms, I focus on only those firms that are contained in the Compustat database. This decision means that a variety of entries are excluded, including government agencies, non-profit organizations, and private entities that are not publicly traded (e.g., Fidelity Investments and Visa). Nonetheless, this choice is the only way to insure a consistent set of variables to analyze.

Each entry is assigned the Compustat identifier associated with the firm at the time of the innovation. These assignments are not always apparent, but can be determined by reviewing the corporations' history using the Hoover's directory, Lexis-Nexis, the SDC Mergers and Acquisitions database, and on-line searches. Thus, for instance, an innovation by Wachovia Bank in 1999 would be assigned to Compustat GVKEY 11247 (denoted "Wachovia Corp-Old"), while one by First Union Bank in that year would be assigned to GVKEY 4739 (denoted "Wachovia Corp," reflecting the fact that First Union acquired Wachovia in 2001 and assumed its name). In some cases, Compustat has multiple listings for a single firm (typically when a firm has a highly visible subsidiary or a tracking stock, but also when the firm releases "pro forma" earnings in addition to those computed in a standard manner). In these cases, I assign the innovation to the record of the parent firm that uses the standard definition of earnings. I drop the other records associated with the firm from the analysis.

I download from Compustat a wide variety of financial data on all firms with at least one *Wall Street Journal* innovation and all firms with a primary assignment to Standard Industrial Classification (SIC) codes 60 through 64 and 67. The choice of these industries is driven by the SIC scheme: I included all firms in "Finance, Insurance and Real Estate" except for SIC class 65, which contains real estate operators. Very few innovations were associated with SICs 673 and 6798, "Trusts" and "Real Estate Investment Trusts." In diagnostic regressions discussed below, I repeat the analysis below without these categories.[8]

The second source is the records of the PTO. The PTO has an on-line database that summarizes all patents awarded since 1976. Following the procedure in Lerner (2002), I identify all patents assigned to relevant U.S. Patent Classification subclasses. I use a somewhat broader set of patent subclasses than that paper for two reasons. First, because the innovations database includes a broad array of bank and insurance

[8]I also use other sources to supplement Compustat for one measure: the time the firm has been publicly traded, a measure that is frequently incomplete in Compustat. If missing, I use the date of the IPO as reported in the SDC Corporate New Issues database. If not included here, I use the first date the firm in which was listed in CRSP or Datastream. As a result, the earliest firms are listed as going public in December 1925.

innovations, I wish to be sure that all relevant patents are captured. Second, the PTO initiated in 2000 a "second review" of patent applications in class 705, in which many of the most controversial Internet-related patents were classified. Since this date, there has been a tendency of applicants to seek to get their financial applications classified in Class 902. I employ all patents with a primary assignment to subclasses 705/4, 705/35 through 705/45, and 902/1 through 902/41.

In all, I identify 1969 patents awarded between 1990 and 2002 and the entity to which the patent was assigned (if any). I once again code these with the appropriate Compustat firm identifier, following the procedure outlined above. There are 922 distinct assignee-patent pairs where the assignee is listed in Compustat.

Table 2 summarizes the innovators and patentees most frequently found in the databases. Panel A, which summarizes the distribution of innovators, highlights the frequency of stories about some of the largest financial institutions. The two most frequent innovators, Merrill Lynch and Citigroup, also appear on the list of leading patentees. Information technology firms and data vendors dominate the list of patentees. Two of these firms, IBM and Reuters, also appear on the list of financial innovators.

The third source is academic-practitioner finance journals. I want to characterize the extent to which each firm is close to the academic frontier. I employ a proxy similar to that in Lerner (2002): the firm's representation on the editorial boards of four leading academic-practitioner journals.[9] I calculate each firm's editorial board seats at the beginning of each year. I count a firm that is a sponsor of a journal as having the equivalent of two editorial board seats. While this proxy is undoubtedly crude (the overwhelming majority of institutions never serve on such boards, even if they may have academic contacts in other ways), it nonetheless appears to at least roughly identify many firms that have strong academic ties.

3. The Origins of Financial Innovations

I now turn to understanding how my measure of financial innovation relates to the characteristics of the potential innovators. I first perform some cross-tabulations, and then undertake a series of regression analyses.

Table 3 compares the features of all *Wall Street Journal* innovators with all firms with a primary assignment to the financial services industry. Each firm-year pair is used as a distinct observation (and assumed to be independent). Inspired by the discussion in Section 2 above, I examine the firms along several dimensions:

- *Total assets.* I use assets (rather than employees or revenues) for several reasons. The measure is more frequently available in Compustat than employees: using assets rather than employees increases the sample size by 56%. I also believe it better conveys the scale of activity for many institutions which may have considerable

[9]The journals employed were *Financial Analysts Journal*, *Financial Management*, the *Journal of Applied Corporate Finance*, and the *Journal of Portfolio Management*. These journals were selected using a variety of sources, including Alexander and Marby (1994), McNulty and Boekeloo (1999), and various on-line compilations by the Institute for Scientific Information.

resources under management, but may have a relatively modest number of employees or revenue flows from fees. Assets are in millions of 2002 dollars.

- *Time the firm has been publicly traded.* While ideally I would have a measure of the firm's overall age, this is a frequently used proxy.
- *Profitability of the firm.* I wish to capture a measure of relative profitability that is unaffected by capital structure choices. Thus, I use the ratio of earnings before interest, debt, taxes, depreciation, and amortization (EBITDA) to total revenues.
- *Leverage.* I employ the ratio of the book value of the firm's long-term debt to total capitalization (the book value of its long-term debt and preferred stock plus the market value of its common stock).
- *Other financial firms in zip code.* In order to capture the presence of localized spillovers, I compute the number of other financial service firms with a headquarters in the same zip code as the firm in the year of the observation.
- *Financial innovations in zip code.* One possibility suggested by the literature is that spillovers are particularly likely from innovative firms in the same locality. I thus compile the count of the total number of financial innovations in the same year by firms with a headquarters in the same zip code as the firm. This measure is highly correlated with the count of other financial firms, so I only use one of the variables in the regression at any time.[10]
- *The ratio of editorial board seats to assets.* I compute the total number of editorial board seats of and editorial sponsorships by each financial institution in a given year

[10]Correlation coefficients between the other measures are modest. The next highest correlation is between assets and leverage (a coefficient of 0.106).

as described above, and normalize it by the total assets (in billions of 2002 dollars) of the firm.

These univariate comparisons do not, of course, have any controls for industry characteristics. To partially address this issue, I also undertake the comparisons for the subset of firms whose primary assignment is to SIC codes 60 through 64 and 67.

The table highlights that the fact that innovators tend to be larger and older. They are less likely to be located in zip codes where there are many financial firms and financial innovations, a pattern that remains true even when I look at the subset of financial service firms. Innovators are likely to have stronger academic ties. The results regarding profitability (EBITDA margin) and leverage are mixed: the results in the sample as a whole are inconsistent or insignificant, but innovators are more profitable and more leveraged when only financial service firms are compared. In any case, our interpretation of these results must be cautious. Not only is the absence of controls for industry, time period, and company location troubling, but the observations are clearly not independent.

Table 4 examines how the propensity to innovate varies with firm size. I divide the firm-year observations into quartiles based on assets (expressed in 2002 dollars). In the table, I present the number of innovations awarded in each year per billion dollars of assets (again in 2002 dollars) for each size quartile. The greater propensity of smaller firms to innovate is apparent.[11] Once again, though, our interpretation of the patterns must be cautious.

I address these concerns in Tables 5 through 7, which examine the determinants of innovations in a regression framework. Following the template of Hausman, Hall, and Griliches (1984), I employ Poisson and negative binomial specifications. Both are well suited for handling this type of non-negative integer dependent variable, though the negative binomial specification is frequently preferred due to its more flexible features.

I address the panel nature of the data set in two ways. First, I pool all observations, employing each observation separately (though computing heteroskedastic-adjusted standard errors that reflect the presence of multiple observations for each firm). I then estimate random effects regressions, which essentially combine information from fixed effects regressions (which add a dummy variable for each firm) and within regressions (that use only one observation from each firm). In the pooled regressions, I include dummy variables to control for the nation in which the company has its headquarters, its three-digit SIC code, and the year of the observation; in the random effects ones, I only control for the year (due to the presence of firm-level controls).

[11]These patterns—and those discussed below—continue to hold when I divide firms by employees rather than assets. The ratio of the count of innovations to employees is 13.7 times greater for the quartile of smallest firms than for the quartile of the largest firms. The ratio decreases monotonically with firm size: the ratio for the smallest firms is 5.8 times greater than for the second largest quartile and 3.0 times greater than the third largest quartile.

Table 5 presents an analysis of the impact of firm size on innovation. I use as observations three sets of firms: those with at least one *Wall Street Journal* innovation, those with at least five financial patents, and all firms with a primary assignment to Standard Industrial Classification (SIC) codes 60 through 64 and 67.[12] I first simply use the logarithm of size as an independent variable, and then employ a piece-wise specification. In the latter case, four separate independent variables take on the value of the logarithm of size if size falls into that quartile, and zero otherwise.

The size measures are consistently different from zero at the one-percent confidence level: larger firms, not surprisingly, are more innovative. A natural question is whether the elasticity of innovations with respect to size is greater or less than one. In other words, does a 10% increase in size lead to more or less than a 10% increase in innovations? To examine this, I exponentiate the coefficients and subtract one: thus, a coefficient of 0.693 would translate into an elasticity of one. The implied elasticities are consistently less than one, with the exception of the smallest-quartile firms in the second and fourth regressions. In the final line, I test whether these differences from one are significant. In seven out of eight regressions, the null hypothesis that the elasticity is equal to one can be rejected at the ten-percent confidence level; in five out of eight, it can be rejected at the five-percent level. This finding of an elasticity of less than one can be contrasted with the consensus in the literature, which depicts innovation being undertaken disproportionately by the largest financial institutions (e.g., Tufano (2003)).

[12]The reason for using a higher cutoff for patenting is that there were many more such awards than innovations in our database.

In Tables 6 and 7, I estimate similar equations that examine the influence of the other proposed explanatory factors. Each pair of columns in Table 6 is similar in structure. In the first column, I report the results of six separate regressions, in which one of the additional independent variables is used along with a variety of control variables.[13] In the second column, I report the result of a regression that employs all of the independent variables simultaneously (though, as noted above, I only use one of the two zip code-based measures). In Table 7, I rerun the regressions reported in second column of these pairs (focusing on the negative binomial specifications) to explore the robustness of the results. The reported regressions include those where (a) firms not based in the United States are eliminated, (b) only innovations ranked as particularly important (see the discussion in Section 2) are included,[14] (c) an additional control for R&D spending is added,[15] and (d) a correction is made to the regression specifications for the possible incidence of too many observations with no innovations.[16]

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[13]I employ the logarithm of all independent variables that are not ratios. In order to include observations with a value of zero, I add one to each independent variable before taking the logarithm.

[14]The reported results here use all innovations classified as "As" and "Bs." The results using only "As" are similar.

[15]I assume that all firms that do not report R&D spending in their financial statements perform no R&D. In point of fact, most financial services firms do not report R&D spending, even if they undertake substantial R&D (see Long (2003)). 98% of the firms in the sample with a primary assignment to the financial service industries do not report positive R&D. For instance, neither Citigroup nor Merrill Lynch report any R&D between 1990 and 2002. Thus, I must approach this measure with caution.

[16]In addition, I undertake a variety of additional analyses that are not reported. These including deleting firms that are not assigned to SIC codes 60 through 64 and 67, deleting trusts and real estate investment trusts, and weighting the observations to reflect whether the firm is the sole focus of the story or is featured alongside with other firms. The results are little changed.

The key results of Table 6 and 7 are as follows:

- Older firms appear to be associated with more innovations in the first set of random effects regressions, but this result does not appear to be robust to modifications of the specification.
- Less profitable firms are consistently significantly more innovative. In the second regression in Table 6, a one standard deviation increase in the ratio of EBITDA to sales translates into a 36% decline in the predicted rate of innovation.
- More levered firms are less innovative in the regressions with random effects; no such pattern appears in the pooled regressions. This suggests that as individual firms become more levered, the rate of financial innovation is likely to decrease, but that this pattern does not appear in a cross-section of firms.
- More financial innovations occurring in a firm's zip code are associated with less innovation in the random effects regressions.
- Closer ties to academia are consistently statistically associated with more innovation, though the magnitude of the effect is more modest. In the second regression of Table 6, a one standard deviation increase in the ratio of editorial board seats to assets leads to a 7% increase in the expected rate of innovation.

4. How Does Innovation Before and After *State Street* Differ?

The second analysis examines changes associated with the dramatic shift in the ability to appropriate discoveries associated with the *State Street* decision. While I can say little about how the decision affected the overall rate of financial innovation—the pace of innovation may have been affected by many other considerations, such as tax policy and other regulatory shifts—I can examine whether the distribution of innovators was affected by the policy change.

Table 8 summarizes regressions similar to those in the fourth and eighth columns of Table 5 and the fourth and eighth column of Table 6. (Once again, I focus on the negative binomial estimations.) In this estimate, I include a second set of independent variables, which consist of interactions between the key independent variables of interest and a dummy variable denoting if the observation is from the year 2000 or after. In Panel A, I report the coefficients and the associated t-statistics of the interaction terms. In Panel B, I report the implied coefficients before and after 2000.

The clearest pattern to emerge from the table is the substantial increase in the coefficient on assets in the post-*State Street* era. The implied elasticities prior to 2000 are all less than one (consistent with the analysis in Table 5). In 2000 and after, however, the elasticities are (in all but one reported case and the overwhelming majority of the unreported ones) greater than one. In many cases, the differences from one are statistically significant.

The results regarding the other independent variables are weaker. The one result worth commenting on is the apparent decline in the significance of the ratio of editorial board seats to assets. Rather than being positive, as is the case before 2000 and in the regressions reported above, the coefficient is now negative in both reported regressions.

In one case, the interaction term is significant at the five-percent confidence level. Our interpretation of this result must be cautious, as in the other reported regression (and in many of the unreported ones), the interaction term is not statistically significant.

It is important to pause to emphasize the importance of caution when interpreting the results. Even if the coefficients are significant, the change may not have been caused by the *State Street* decision. Moreover, many of the effects of financial patenting may not make themselves felt for years to come. In addition, the modest number of observations after the *State Street* decision implies that any changes are likely to be observed with considerable imprecision.[17]

The final set of analyses examines the filing of patent applications by the firms in our sample. I replicate the analyses above, in the hopes of getting a better understanding of causes of the changes seen above. If the patterns in patenting mirror the changes seen in recent years in the nature of financial innovations, I may be more confident in attributing the changes to this policy shift.

Table 9 repeats the analysis in Table 3, now comparing the features of all firms with five or more financial patent awards between 1990 and 2002 and all firms with a

[17]The need for caution in the interpretation of this analysis is also underscored by an examination of the coefficients from (unreported) annual regressions of the number of innovations on firm size (using the controls above). While the coefficients on firm size are the highest during the period 2000 to 2002, and there is a sharp discontinuity between 1999 and 2000, the coefficient is quite unstable from year-to-year. In addition, the influence of other aspects of the economic environment is apparent: for instance, the coefficient is particularly low in 1998 and 1999, apparently due to the large number of stories on smaller firms that had recently raised venture financing or gone public.

primary assignment to the financial services industry. As before, each firm-year pair is used as a distinct observation (and assumed to be independent).

Similar to the analysis of innovators, patentees tend to be larger and older. They are less likely to be located in zip codes where there are many financial firms and financial innovations, a pattern that remains true even when I look at the subset of financial service firms. Unlike the analysis of innovators, stronger academic ties are only weakly associated with more patents. As above, the results regarding profitability and leverage are mixed: the results are inconsistent or insignificant.

Table 10 replicates the analysis in Table 4, examining how the propensity to innovate and patent varies with firm size. Again, I divide the firm-year observations into quartiles based on assets (expressed in 2002 dollars). In the table, I present the number of patents awarded in each year per billion dollars of assets (again in 2002 dollars) for each size quartile. The greater propensity of smaller firms to patent is apparent, though the magnitude of the effect is somewhat smaller here than in Table 4.

I then turn to examining patenting in a regression framework. A general consensus in the productivity literature is that it makes sense to examine the filing date of patent applications, rather then their award dates. The processing times for these awards differ across time and technology classes. Moreover, studies suggest that the lag between the patent application filing and the R&D activity is minimal (Hall, Griliches, and Hausman (1986)). While this approach is certainly desirable, it has the consequence of limiting the time period over which I can examine patenting behavior. Applications are often held confidential in the United States prior to award, so I cannot ascertain how many applications each firm has made in recent years. I consequentially restrict the analysis to patents applied for prior to 2000.

Table 11 corresponds to the analyses of innovations in the Panels A of Tables 5 and 6. Panel A of Table 11 highlights the fact that the elasticity of patenting with respect to size is typically well less than one, a difference that is generally both economically and statistically meaningful. Panel B reveals both some similarities with and differences from the patterns seen among innovations. Like the innovators, patentees tend to be less profitable. Unlike them, however, they tend to be *less* likely to have an academic affiliation. In addition, patentees appear to be significantly less leveraged, a pattern found in some of the innovation regressions. The results remain robust when other specifications (e.g., akin to those in Panels B of Tables 5 and 6) are used.

The analysis of patenting is intended to be exploratory, and my conclusions must of necessity be tentative. Certainly, I cannot attribute the increased elasticity of innovation with respect to firm size after 1999 to any difference in the nature of firms seeking patent protection. It may well be, however, that the value of these patents are greater for larger firms (perhaps due to their greater ability to enforce these awards (Lerner (1995))). But the increased elasticity could also reflect other, totally unrelated changes. It is also tempting to relate the seeming decline in the importance of academic ties in spurring innovation to the lesser importance of this activity as a determinant of patenting, but this claim again would be beyond what the evidence would support.

5. **Conclusions**

In this paper, I analyze the sources of financial innovations between 1990 and 2002. I find evidence that suggests that small firms are as innovative or even more innovative than their larger peers. Less profitable firms and those with stronger ties to academia also innovate more. Recent evidence suggests that these relationships may be changing after the *State Street* decision, which greatly encouraged financial patenting.

This paper is very much of an initial look at these issues. Far more could be done to relate changes in the rate and type of innovations to shifts in the tax, regulatory, and overall economic environment. In order to fully explore these issues, it will probably be necessary to look over a longer time frame. A second area that would reward exploration is tracing out how these breakthroughs affected the profitability and growth of the innovators and their competitors.

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Appendix A: Summary of Patent Policy Changes

The fervent in the U.S. patent system—and in financial patents in particular—had its origin in two shifts. Neither was thoroughly discussed at the time. Nor did policymakers appear to appreciate the *interaction* between these two changes:

- The first was a seemingly technical shift in the appellate process. Since the birth of the republic, almost all formal disputes involving patents have been tried in the federal judicial system. The initial litigation must occur in a district court. Before 1982, appeals of patent cases were heard in the appellate courts of the various circuits. These circuits differed considerably in their interpretation of patent law, with some of them more than twice as likely to uphold patent claims than others. These differences persisted because the Supreme Court rarely heard patent-related cases. In 1982, the U.S. Congress established a centralized appellate court for patent cases: the Court of Appeals for the Federal Circuit (CAFC). The CAFC was staffed mostly with judges in the federal system that had experience as patent attorneys. Not surprisingly, many had an outlook that was sympathetic to the patent system. Over the next decade, in case after case, the court significantly broadened patent-holders' rights. The court expanded patent-holders' rights along a number of other dimensions as well.

- The operation of the U.S. Patent and Trademark Office (PTO) itself also changed over this period. Over the course of the 1990s, Congress converted the PTO from a tax-revenue-funded agency that collected nominal fees for patent applications into one funded solely by fees. Indeed, the PTO has become a "profit center" for the government, collecting more in application fees than it costs to run the agency. These effects of this policy change has been severe financial pressures, particularly in emerging industries. Consequently, awards of patents in several critical new technologies have been delayed and highly inconsistent.

With this background, I will now turn the specifics of financial and business method patents. Since the early days of the twentieth century, there has been considerable doubt as to whether methods of doing business fell under the definition of patentable subject matter, namely "any new and useful process, machine, manufacture, or composition of matter."[1] While the United Sates did not explicitly forbid business method patents, as many countries did, there was still a presumption that they did not fall into these four categories and hence were not patentable.[2]

[1] 35 U.S.C. 101.

[2] The crucial decision in establishing such an exception was *Hotel Security Checking Co. v. Lorraine Co.*, 160 F. 467 (2d Cir. 1908), which concerned a restaurant bookkeeping system.

This presumption changed with the CAFC's July 1998 decision in *State Street Bank & Trust v. Signature Financial Group*.[3] State Street Bank sued to have Signature's 1993 patent on software to fix closing prices of mutual funds for reporting purposes declared invalid. While State Street's argument prevailed in the Federal District of Massachusetts, where a summary judgment of patent invalidity was issued. The CAFC reversed the decision on appeal. In its decision, the appellate court explicitly rejected the notion that there was a "business method" exception for patentability. Rather, the CAFC stated "the question of whether a claim encompasses statutory subject matter should not focus on which of the four categories of subject matter a claim is directed to … but rather on the essential characteristics of the subject matter, in particular, its practical utility."[4] State Street's certiorari petition to the Supreme Court, asking them to review this decision, was rejected in January 1999.

Assessing the extent to which this decision has affected firm behavior is difficult. Certainly, financial patents have issued for many years. (The patent issued to Merrill Lynch in 1982 for its cash management account was one highly publicized example.) But interviews that Peter Tufano and I have conducted suggest that the *State Street* decision has spurred many financial institutions to reconsider their policies regarding patenting. Certainly, the volume of financial patent applications has increased dramatically (Lerner (2002)). An examination of the financial patents that issued both before and after the *State Street* decision underscores many of the issues regarding examination quality discussed above. Numerous examples exist of patents covering "discoveries" that actually have been known for many years.

[3]149 F.3d 1368 (Fed. Cir. 1998).

[4]*State Street*, 149 F.3d at 1375.

Appendix B: Examples of Included Stories

- Announcements of new financial products and processes.
- Announcements of new products incorporating an improvement.
- Plans to develop or introduce new products or processes.
- Experimental new products.
- Joint ventures if an innovation is mentioned as the goal.
- Government grants and contracts to fund something new and innovative (even if government is only seeking to award a contract). (Unlike for new products and processes, for grants and contracts I required that there must be some clear evidence that something innovative is sought):
- Government approvals (or applications for approval) of new products, including approvals by foreign governments.
- Innovative new applications or combinations of existing product.
- Applications of new technology to finance: "High-yield junk bonds auctioned electronically."
- Articles about innovation even if it concerned only the intention to surpass some technological hurdle. My reasoning is that an invention or innovation probably spurred the attempt. The fact that the research may ultimately fail is not a concern, as even many patented inventions turn out to be useless.
- Innovative applications on the Internet: "First application of online banking." I do not include announcements of new web pages unless there is a clear innovation, *i.e.*, the first application of a new idea.

Appendix C: Examples of Excluded Stories

- Cases in which marketing issues are central and technological achievements only secondary.
- Reports on the spread or diffusion of an existing technology.
- Expansion of a market: "Branch banking to hit Hawaii."
- Letters to the editor, editorials, or corrections.
- Political decisions, new laws, and regulations. (But patents issued and government approvals of new products are included.)
- Articles concerning standards, even if they are technological standards.
- New design or product in which the improvement is clearly esthetic rather than technological.
- Government grants or contracts for production of an existing product, or one that is not clearly innovative.
- New products or innovations occurring in foreign markets, which have no consequences for U.S. producers or consumers.
- New issues of stocks or bonds where the security types.
- Patent infringement cases or stories about licensing technology. These cases concern ownership of intellectual property, not its creation.
- New scientific discoveries. Here, the discovery does not point to a specific new product or process; if it had, I would include it.

Table 1. Summary of stories about innovations. The table provides information on the distribution of news stories about financial innovations in the *Wall Street Journal*. Panel A presents the breakdown of all news stories by year. Panel B provides a breakdown of the types of innovation. Panel C tabulates the mentions of Compustat-listed entities in these stories by year. Panel D presents the distribution of the firms in Panel C by their primary Standard Industrial Classification (SIC) code (at the three-digit level).

Panel A: Total Stories by Year		Panel B: Breakdown of Innovation Types		Panel C: Mentions of Compustat-Listed Entities by Year		Panel D: Distribution of Compustat-Listed Innovators by 3-Digit SIC Code	
1990	48	Security underwriting; trading	33.5%	1990	27	Securities brokers & dealers (621)	23.5%
1991	61	Asset management; pensions	26.2%	1991	32	Commercial banks (602)	22.3%
1992	47	Combination of classes; other	17.7%	1992	30	Other non-depository credit insts. (619)	8.2%
1993	49	Retail/mortgage banking	11.6%	1993	22	Computer programming & related (737)	6.7%
1994	38	Credit cards	5.2%	1994	28	Books (273)	4.4%
1995	29	Insurance	5.2%	1995	18	Newspapers (271)	3.5%
1996	34	Commercial banking	0.6%	1996	21	Motor vehicles & equipment (371)	2.9%
1997	54			1997	40	Miscellaneous business services (738)	2.6%
1998	49			1998	16	Fire, marine & casualty insurance (633)	2.1%
1999	55			1999	40	Petroleum refining (291)	2.1%
2000	74			2000	46	Telephone (481)	2.1%
2001	55			2001	25	Life insurance (631)	1.8%
2002	58			2002	42	Services w/ securities exchange (628)	1.5%

Table 2. Most frequently represented Compustat-listed innovators and patentees. The table lists those firms who had the greatest number of *Wall Street Journal* stories about innovations and patent awards between 1990 and 2002 while listed in Compustat.

Panel A: Innovators		**Panel B: Patentees**	
Company Name	*Number*	*Company Name*	*Number*
Merrill Lynch	20	Hitachi	76
Citigroup	15	International Business Machines	55
American Express	13	NCR	55
Citicorp	13	Citigroup	47
McGraw-Hill	13	Fujitsu	47
Charles Schwab Corp.	11	AT&T	33
Dow Jones	10	Diebold	30
Morgan Stanley	10	Toshiba	23
Goldman Sachs	9	Merrill Lynch	18
Bear Stearns	8	First Data	14
International Business Machines	8	Citicorp	13
Reuters Group	7	Microsoft	12
Bank of America	6	Xerox	12
Barclays	6	Electronic Data Systems	10
Chase Manhattan	6	Lucent	10
J P Morgan	6	Reuters Group	10
		Unisys	10

NOTE: These tabulations are based on the assignment to the Compustat GVKEY code, which typically continues with a firm even as it changes its name. Thus, Citigroup includes activity by Citigroup after the 1998 merger and by the Travelers Group (and predecessor entities) previously. Citicorp includes activity by Citicorp prior to the 1998 merger.

Table 3. Characteristics of innovators and other financial firms. The sample consists of 20,916 annual observations of financial innovators and other financial service firms listed in Compustat between 1990 and 2002. The first column summarizes the characteristics of all firms with a primary assignment to the financial service industry. The second and third present the characteristics for all firms undertaking at least one financial innovation (reported in the *Wall Street Journal*) and all innovators who had a primary assignment to the financial service industry. The results of t- and median tests comparing these firms to other financial services firms are also presented.

	All Financial Service Firms	**Innovators**	
		All Firms	*Financial Service Only*
Assets			
Mean	10,899	90,112***	132,304***
Median	516	28,693***	57,115***
Years since IPO			
Mean	8.6	21.4***	18.7***
Median	6	16***	18***
EBITDA Margin			
Mean	0.18	0.24***	0.32***
Median	0.28	0.23***	0.31***
Leverage			
Mean	0.28	0.29	0.33***
Median	0.21	0.26***	0.31***
Other Financial Firms in Zip Code			
Mean	294	194***	153***
Median	3	2***	2***
Financial Innovations in Zip Code			
Mean	2.46	1.76***	1.40***
Median	0	0***	0***
Editorial Board Seats/Assets Ratio			
Mean	0.0005	0.0031***	0.0034***
Median	0	0***	0***

* = significant at the 10% confidence level; ** = significant at the 5% level; *** = significant at the 1% level.

Table 4. Distribution of innovations across firm size quartiles. The sample consists of 20,916 annual observations of financial innovators and other financial service firms listed in Compustat between 1990 and 2002. The table divides the firm-year observations based on assets (in 2002 dollars) in the year of the observation. The table then reports the average annual number of innovations per billion dollars of assets (also in 2002 dollars).

Asset Size Quartile	*Number of Firm-Year Observations*	*Innovations/Assets ($B 2002)*
Under $148.27 million	5210	0.0389
Between $148.27 and $554.70 million	5211	0.0058
Between $554.71 and $2,487.26 million	5211	0.0043
Over $2,487.26 million	5210	0.0012
p-Value, F-test of difference		0.022

Table 5. Regression analyses of the impact of firm size on innovative activity. The sample consists of 20,916 annual observations of financial innovators, financial patentees, and other financial service firms listed in Compustat between 1990 and 2002. The regressions employ pooled observations or random effects, with a Poisson or negative binomial specification. The dependent variable in each regression is the count of innovations by a given firm in a given year. The independent variables are the logarithm of assets (in millions of 2002 dollars) or the logarithm of assets if the observation is in each quartile. Additional control variables in the pooled regressions (not reported) include dummies for the location of the company, the three-digit Standard Industrial Classification class of the firm, and the year of the observation; the random effects regressions employ the year dummies. Standard errors (heteroskedastic-adjusted in the pooled regressions) are in parentheses.

	Panel A: Pooled Regressions				**Panel B: Random Effects Regressions**			
	Poisson		*Negative Binomial*		*Poisson*		*Negative Binomial*	
Logarithm of assets	0.57		0.60		0.60		0.62	
	***(0.07)		***(0.06)		***(0.04)		***(0.04)	
Log of assets if assets are in smallest quartile		0.71		0.83		0.56		0.63
		***(0.27)		***(0.25)		***(0.17)		***(0.17)
Log of assets if assets are in second quartile		0.53		0.61		0.41		0.44
		***(0.20)		***(0.18)		***(0.12)		***(0.12)
Log of assets if assets are in third quartile		0.55		0.62		0.46		0.49
		***(0.16)		***(0.15)		***(0.09)		***(0.09)
Log of assets if assets are in largest quartile		0.57		0.62		0.54		0.56
		***(0.11)		***(0.10)		***(0.06)		***(0.06)
Location dummy variables	Y	Y	Y	Y	N	N	N	N
SIC code dummy variables	Y	Y	Y	Y	N	N	N	N
Year dummy variables	Y	Y	Y	Y	Y	Y	Y	Y
Number of observations	20,821	20,821	20,821	20,821	20,821	20,821	20,821	20,821
Log likelihood	-1070.6	-1069.3	-1044.8	-1043.1	-1144.0	-1140.8	-1138.3	-1135.1
p-Value, chi-squared test	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
p-Value, F-test of equality of coefficients		0.385		0.207		0.100		0.091
p-Value, test of equality of elasticity to 1	0.086	0.007	0.133	0.007	0.021	0.010	0.058	0.020

* = significant at the 10% confidence level; ** = significant at the 5% level; *** = significant at the 1% level.

Table 6. Regression analyses of the other independent variables on innovative activity. The sample consists of 20,916 annual observations of financial innovators, financial patentees, and other financial service firms listed in Compustat between 1990 and 2002. The regressions employ pooled observations or random effects, with a Poisson or negative binomial specification. The dependent variable in each regression is the count of innovations by a given firm in a given year. The independent variables include the logarithm of years since the firm's initial public offering, the ratio of its earnings before interest, taxes, depreciation and amortization to revenues, the ratio of the book value of the firm's long-term debt to total capitalization (the book value of its long-term debt and preferred stock plus the market value of its common stock), the logarithm of the number of financial firms based in the firm's zip code, the logarithm of the number of financial innovations in that year by other companies based in the firm's zip code, and the ratio of the firm's editorial board seats on academic-practitioner journals to assets. Additional control variables in the pooled regressions (not reported) include the logarithm of assets and dummies for the location of the company, the three-digit Standard Industrial Classification class of the firm, and the year of the observation; the random effects regressions employ assets and the year dummies. The first column of each pair represents the coefficients from six separate regressions using each independent variable in turn; the second column reports the coefficients from a single regression. Standard errors (heteroskedastic-adjusted in the pooled regressions) are in parentheses.

	Panel A: Pooled Regressions				**Panel B: Random Effects Regressions**			
	Poisson		*Negative Binomial*		*Poisson*		*Negative Binomial*	
Log of years since firm's IPO	0.10	0.10	0.12	0.10	0.27	0.20	0.26	0.19
	(0.08)	(0.10)	(0.08)	(0.10)	***(0.08)	**(0.10)	***(0.08)	**(0.10)
EBITDA/revenues ratio	-0.67	-0.65	-0.71	-0.72	-0.64	-0.65	-0.64	-0.65
	***(0.17)	***(0.22)	***(0.14)	***(0.17)	***(0.13)	***(0.16)	***(0.13)	*** (0.17)
Leverage ratio	-0.47	-0.45	-0.64	-0.51	-1.42	-1.38	-1.32	-1.24
	(0.58)	(0.57)	(0.61)	(0.59)	***(0.37)	***(0.40)	***(0.38)	***(0.40)
Log of financial firms based in zip code	-0.02		-0.002		-0.11		-0.12	
	(0.05)		(0.05)		***(0.04)		***(0.04)	
Log of financial innovations by others in zip code	-0.14	-0.09	-0.09	-0.04	-0.38	-0.43	-0.41	-0.46
	(0.14)	(0.16)	(0.14)	(0.15)	***(0.10)	***(0.12)	***(0.10)	***(0.12)
Editorial board seats/assets ratio	0.03	0.08	0.04	0.08	0.04	0.10	0.04	0.11
	***(0.005)	***(0.01)	***(0.01)	***(0.01)	***(0.02)	***(0.03)	***(0.02)	***(0.03)
Logarithm of assets	Y	Y	Y	Y	Y	Y	Y	Y
Location dummy variables	Y	Y	Y	Y	N	N	N	N
SIC code dummy variables	Y	Y	Y	Y	N	N	N	N
Year dummy variables	Y	Y	Y	Y	Y	Y	Y	Y
Number of observations	NA	15,937	NA	15,937	NA	15,937	NA	15,937
Log likelihood	NA	-873.9	NA	-849.7	NA	-908.6	NA	-903.1
p-Value, chi-squared test	NA	0.00	NA	0.00	NA	0.00	NA	0.00

* = significant at the 10% confidence level; ** = significant at the 5% level; *** = significant at the 1% level.

NA = not applicable (column consists of coefficients from multiple regressions, rather than a single regression).

Table 7. Robustness of the results. The sample consists of 20,916 annual observations of financial innovators, financial patentees, and other financial service firms listed in Compustat between 1990 and 2002. The regressions employ pooled observations or random effects, with a negative binomial specification (except for the last regression, which employs a Poisson specification). The dependent variable in each regression is the count of innovations by a given firm in a given year. The independent variables include the logarithm of years since the firm's initial public offering, the ratio of its earnings before interest, taxes, depreciation and amortization to revenues, the ratio of the book value of the firm's long-term debt to total capitalization (the book value of its long-term debt and preferred stock plus the market value of its common stock), the logarithm of the number of financial firms based in the firm's zip code, the logarithm of the number of financial innovations in that year by other companies based in the firm's zip code, and the ratio of the firm's editorial board seats on academic-practitioner journals to assets. Additional control variables in the pooled regressions (not reported) include the logarithm of assets (in millions of 2002 dollars), dummies for the location of the company, the three-digit Standard Industrial Classification class of the firm, and the year of the observation; the random effects regression employs assets and the year dummies. The first pair of regressions eliminate firms not based in the United States; the second pair only use discoveries ranked as highly innovative; the third pair adds the ratio of R&D to assets as a control variable; and the final pair employs an adjustment for extra zeros in the sample. Standard errors (heteroskedastic-adjusted in the pooled regressions) are in parentheses.

	Negative Binomial Specification							**Poisson**
	Eliminating non-US firms		*"Good" innovations*		*R&D control*		*Zero adjustment*	
	Pooled	*Rand. eff.*	*Pooled*	*Rand.eff.*	*Pooled*	*Rand.eff.*	*Pooled*	*Pooled*
Log of years since firm's IPO	0.06	0.10	0.03	0.14	0.10	0.19	0.14	0.14
	(0.10)	(0.10)	(0.12)	(0.11)	(0.10)	**(0.10)	(0.10)	(0.12)
EBITDA/revenues ratio	-0.78	-0.73	-0.88	-0.68	-0.72	-0.65	-0.80	-0.74
	***(0.16)	***(0.16)	***(0.16)	***(0.18)	***(0.17)	***(0.17)	***(0.21)	***(0.24)
Leverage ratio	-0.19	-1.00	-0.69	-1.46	-0.51	-1.24	-0.81	-0.68
	(0.64)	**(0.41)	(0.68)	***(0.48)	(0.59)	***(0.40)	(0.77)	(0.67)
Log of financial innovations by others in zip code	-0.08	-0.46	-0.03	-0.43	-0.04	-0.46	-1.35	-1.27
	(0.15)	***(0.13)	(0.17)	***(0.14)	(0.15)	***(0.12)	**(0.60)	***(0.50)
Editorial board seats/assets ratio	0.08	0.11	0.08	0.11	0.08	0.11	0.09	0.08
	***(0.01)	***(0.03)	***(0.01)	***(0.03)	***(0.01)	***(0.03)	***(0.01)	***(0.01)
R&D/assets ratio					0.12	0.13		
					***(0.03)	(0.10)		
Logarithm of assets	Y	Y	Y	Y	Y	Y	Y	Y
Location dummy variables	N	N	Y	N	Y	N	Y	Y
SIC code dummy variables	Y	N	Y	N	Y	N	Y	Y
Year dummy variables	Y	Y	Y	Y	Y	Y	Y	Y
Number of observations	15,034	15,034	15,937	15,937	15,937	15,937	9,951	9,951
Log likelihood	-775.2	-816.9	-634.8	-693.3	-849.6	-902.9	-624.6	-636.4
p-Value, chi-squared test	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* = significant at the 10% confidence level; ** = significant at the 5% level; *** = significant at the 1% level.

Table 8. Regression analysis of the impact of firm characteristics on innovative activity with interaction terms for observations after the *State Street* decision. The sample consists of 20,916 annual observations of financial innovators, financial patentees, and other financial service firms listed in Compustat between 1990 and 2002. The regressions employ pooled observations or random effects, with a negative binomial specification. The dependent variable in each regression is the count of innovations by a given firm in a given year. The independent variables in the first and third regressions are the logarithm of assets (in millions of 2002 dollars) if the observation is in each asset quartile (not reported) and interactions between these terms and a dummy denoting if the observation is in 2000 or after. The independent variables in the second and fourth regressions include the logarithm of years since the firm's initial public offering, the ratio of its earnings before interest, taxes, depreciation and amortization to revenues, the ratio of the book value of the firm's long-term debt to total capitalization (the book value of its long-term debt and preferred stock plus the market value of its common stock), the logarithm of the number of financial firms based in the firm's zip code, the logarithm of the number of financial innovations in that year by other companies based in the firm's zip code, the ratio of the firm's editorial board seats on academic-practitioner journals to assets (all not reported), and interactions between these terms and a dummy denoting if the observation is in 2000 or after. Additional control variables in the pooled regressions (not reported) include the logarithm of assets (in the second regression only), dummies for the location of the company, the three-digit Standard Industrial Classification class of the firm, and the year of the observation; the random effect regressions employ assets (in the fourth regression only) and the year dummies. Standard errors (heteroskedastic-adjusted in the pooled regressions) are in parentheses. Panel B reports the coefficients implied by the regressions for the periods before 2000 and 2000 and after.

Panel A: Interactions Terms in Negative Binomial Regressions

	Pooled Regressions		*Random Effects*	
Log of assets if assets are in smallest quartile	0.61		0.62	
	**(0.30)		*(0.35)	
Log of assets if assets are in second quartile	0.35		0.38	
	(0.29)		(0.25)	
Log of assets if assets are in third quartile	0.49		0.46	
	**(0.21)		***(0.16)	
Log of assets if assets are in largest quartile	0.27		0.28	
	**(0.12)		***(0.08)	
Log of years since firm's IPO		-0.04		-0.16
		(0.16)		(0.15)
EBITDA/revenues ratio		-0.43		-0.56
		(0.27)		*(0.33)
Leverage ratio		0.17		0.13
		(0.75)		(0.65)
Log of financial innovations by others in zip code		0.06		0.14
		(0.28)		(0.23)
Editorial board seats/assets ratio		-1.11		-0.35
		**(0.46)		(3.90)
Logarithm of assets		Y		Y
Location dummy variables	Y	Y	N	N
SIC code dummy variables	Y	Y	N	N
Year dummy variables	Y	Y	Y	Y
Number of observations	20,821	15,937	20,821	15,937
Log likelihood	-1038.2	-848.1	-1128.7	-898.6
p-Value, chi-squared test	0.00	0.00	0.00	0.00

Panel B: Implied Coefficients in Above Regressions

	Pooled Regressions		*Random Effects*	
Log of assets if assets are in smallest quartile				
Pre 2000	0.63		0.40	
2000 and after	1.24		1.02	

Log of assets if assets are in second quartile				
Pre 2000	0.48		0.29	
2000 and after	0.83		0.67	
Log of assets if assets are in third quartile				
Pre 2000	0.46		0.34	
2000 and after	0.95		0.80	
Log of assets if assets are in largest quartile				
Pre 2000	0.53		0.47	
2000 and after	0.80		0.75	
Log of years since firm's IPO				
Pre 2000		0.12		0.24
2000 and after		0.08		0.08
EBITDA/revenues ratio				
Pre 2000		-0.52		-0.42
2000 and after		-0.94		-0.98
Leverage ratio				
Pre 2000		-0.55		-1.28
2000 and after		-0.38		-1.16
Financial innovations by others in zip code				
Pre 2000		-0.05		-0.50
2000 and after		0.01		-0.36
Editorial board seats/assets ratio				
Pre 2000		0.08		0.10
2000 and after		-1.03		-0.25

* = significant at the 10% confidence level; ** = significant at the 5% level; *** = significant at the 1% level.

Table 9. Characteristics of patentees and other financial firms. The sample consists of 20,916 annual observations of financial patentees and other financial service firms listed in Compustat between 1990 and 2002. The first column summarizes the characteristics of all firms with a primary assignment to the financial service industry. The second and third present the characteristics for all firms awarded five or more financial patents and those who had a primary assignment to the financial service industry. The results of t- and median tests comparing these firms to other financial services firms are also presented.

	All Financial Service Firms	**Patentees**	
		All Firms	*Financial Service Only*
Assets			
Mean	10,899	76,348***	210,396***
Median	516	30,572***	132,842***
Years since IPO			
Mean	8.6	24.6***	30.0***
Median	6	18***	25***
EBITDA Margin			
Mean	0.18	0.17	0.37**
Median	0.28	0.17***	0.34***
Leverage			
Mean	0.28	0.19***	0.37***
Median	0.21	0.13***	0.38***
Other Financial Firms in Zip Code			
Mean	294	192***	61***
Median	3	1***	1***
Financial Innovations in Zip Code			
Mean	2.46	1.89***	0.68***
Median	0	0**	0***
Editorial Board Seats/Assets Ratio			
Mean	0.0005	0.0007	0.0033
Median	0	0***	0***

* = significant at the 10% confidence level; ** = significant at the 5% level; *** = significant at the 1% level.

Table 10. Distribution of patents across firm size quartiles. The sample consists of 20,916 annual observations of financial patentees and other financial service firms listed in Compustat between 1990 and 2002. The table divides the firm-year observations based on assets (in 2002 dollars) in the year of the observation. The table then reports the average annual number of patents per billion dollars of assets (also in 2002 dollars).

Asset Size Quartile	*Number of Firm-Year Observations*	*Patents/Assets ($B 2002)*
Under $148.27 million	5210	0.0467
Between $148.27 and $554.70 million	5211	0.0127
Between $554.71 and $2,487.26 million	5211	0.0079
Over $2,487.26 million	5210	0.0024
p-Value, F-test of difference		0.011

Table 11. Regression analyses of the impact of firm size on patenting. The sample consists of 15,961 annual observations of financial innovators, financial patentees, and other financial service firms listed in Compustat between 1990 and 1999. The regressions employ pooled observations, with a Poisson or negative binomial specification. The dependent variable in each regression is the count of successful patent applications filed by a given firm in a given year. The independent variables in Panel A are the logarithm of assets (in millions of 2002 dollars) or the logarithm of assets if the observation is in each quartile. Additional control variables (not reported) include dummies for the location of the company, the three-digit Standard Industrial Classification class of the firm, and the year of the observation. The independent variables in Panel B include the logarithm of years since the firm's initial public offering, the ratio of its earnings before interest, taxes, depreciation and amortization to revenues, the ratio of the book value of the firm's long-term debt to total capitalization (the book value of its long-term debt and preferred stock plus the market value of its common stock), the logarithm of the number of financial firms based in the firm's zip code, the logarithm of the number of financial innovations in that year by other companies based in the firm's zip code, and the ratio of the firm's editorial board seats on academic-practitioner journals to assets. Additional control variables (not reported) include the logarithm of assets and dummies for the location of the company, the three-digit Standard Industrial Classification class of the firm, and the year of the observation. The first column of each pair in Panel B represents the coefficients from six separate regressions using each independent variable in turn; the second column reports the coefficients from a single regression. Heteroskedastic-adjusted standard errors are in parentheses.

Panel A: Analysis of Firm Size				
	Poisson		*Negative Binomial*	
Logarithm of assets	0.41		0.46	
	***(0.08)		***(0.09)	
Log of assets if assets are in smallest quartile		0.82		0.81
		**(0.40)		(0.52)
Log of assets if assets are in second quartile		0.73		0.66
		**(0.32)		*(0.37)
Log of assets if assets are in third quartile		0.58		0.49
		**(0.27)		(0.31)
Log of assets if assets are in largest quartile		0.53		0.54
		***(0.16)		***(0.21)
Location dummy variables	Y	Y	Y	Y
SIC code dummy variables	Y	Y	Y	Y
Year dummy variables	Y	Y	Y	Y
Number of observations	15,886	15,886	15,886	15,886
Log likelihood	-1160.4	-1151.7	-969.8	-963.2
p-Value, chi-squared test	0.00	0.00	0.00	0.00
Panel B: Other Independent Variables				
	Poisson		*Negative Binomial*	
Log of years since firm's IPO	-0.08	-0.01	-0.11	-0.08
	(0.15)	(0.17)	(0.10)	(0.13)
EBITDA/revenues ratio	-0.66	-0.79	-0.91	-0.91
	***(0.15)	***(0.21)	***(0.18)	***(0.28)
Leverage ratio	-1.93	-2.15	-1.76	-1.78
	**(0.85)	**(0.97)	**(0.76)	**(0.81)
Log of financial firms based in zip code	-0.06		-0.11	
	(0.10)		(0.07)	
Log of financial innovations by others in zip code	0.05	-0.01	-0.18	-0.08
	(0.19)	(0.24)	(0.19)	(0.21)
Editorial board seats/assets ratio	-0.36	-0.33	-0.39	-0.32
	***(0.13)	**(0.15)	***(0.12)	***(0.11)
Logarithm of assets	Y	Y	Y	Y
Location dummy variables	Y	Y	Y	Y

SIC code dummy variables	Y	Y	Y	Y
Year dummy variables	Y	Y	Y	Y
Number of observations	NA	11,941	NA	11,941
Log likelihood	NA	-920.9	NA	-771.8
p-Value, chi-squared test	NA	0.00	NA	0.00

* = significant at the 10% confidence level; ** = significant at the 5% level; *** = significant at the 1% level.

NA = not applicable (column consists of coefficients from multiple regressions, rather than a single regression).